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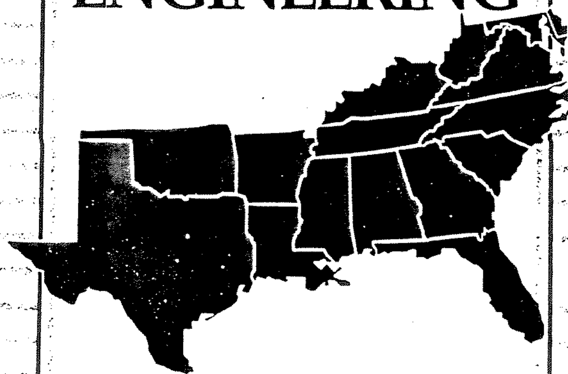

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Natural Regeneration of Southern Bottomland Hardwoods

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Abstract

Many mixed hardwood stands found in bottomlands have been degraded by past harvesting practices that resulted in high grading the stand, thereby leaving the forester few options other than regeneration. Economic considerations usually constrain the choices to some form of complete overstory removal if adequate advance regeneration or sprouting potential is available. Success, in terms of numbers of stems and species composition, requires full release of the regeneration, meaning that trees greater than 2 inches in dbh must be brought back to the ground or deadened. Where regeneration or coppice potential is not adequate, we lack proven methods of establishing natural stands of desirable oaks. A prediction model has been published and can be used to guide decisions on whether regeneration potential is adequate. Experience in other oak types suggests that it is unwise to rely on new germinants to maintain an oak component. If partial cuts are increasingly prescribed for promoting oak regeneration by shelterwood and for uneven-aged management of bottomland hardwoods, then great care must be taken to avoid logging damage to residual stems.

Introduction

Natural community development in southern bottomland hardwood forests frequently results in subclimax stands dominated by sweetgum and red oak or by elm-ash-sugarberry associations that often include an oak component (Hodges, in press). Managers interested in timber or wildlife generally desire to maintain an oak component in regenerating stands; hence, they have favored even-aged regeneration methods such as clearcutting. Naturally regenerated mixed hardwood stands most frequently developed as even-aged stands dominated by faster growing, shade-intolerant species (Johnson and Shropshire, 1983). In general, even-aged management is recommended for maximum timber production (Johnson and Shropshire, 1983), although other management objectives frequently require uneven-aged management.

In this paper we present a conceptual model of natural stand development in even-aged, mixed-species stands that underlies our approach to silvicultural systems in bottomland hardwoods. We discuss alternative regeneration methods and practices, including the impact on residual trees of systems using partial cuts.

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Stand Development Model

Our model is based on one suggested by Oliver (1981), which recognizes four stages in stand development: stand initiation, stem exclusion, understory initiation, and old growth.

The stand initiation stage begins the cycle of stand development in even-aged stands following a major disturbance that removes the previous overstory. The new stand originates from sprouts from existing stumps and roots; from advance regeneration that existed under the previous overstory; or from seedlings.

The seedling component can originate from seed produced by individuals in the previous stand; from seeds produced by individuals in other stands that blew in by wind, were carried in by flood waters, or were brought in by animals; or from a buried seed pool that was maintained by additions from within or outside the previous stand. Thus, there are many pathways by which individual stems are recruited to form the new stand, and site-specific conditions during harvesting may favor one source of regeneration over others. The stand initiation phase persists until the site is fully occupied.

The stem exclusion stage is characterized by intense competition for resources (light, nutrients, and water) among established individuals. Different inherent early growth rates and tolerances for shade, soil waterlogging, and nutrient limitations, as well as actual environmental conditions, determine the outcome. The result is a vertical stratification of individuals and species. The species that eventually dominate the mature stand may have been represented by relatively few individuals during the stand initiation and stem exclusion stages. The development of red oak-sweetgum stands illustrates this important point (Aust et al., 1984; Clatterbuck and Hodges, 1988; Johnson and Krinard, 1976, 1988).

The understory initiation stage begins as scattered individuals in the overstory die and sunlight is allowed to reach the forest floor. New stems, or advance reproduction, appear in the understory and may persist for as long as 30 to 35 years, although oaks and other moderately intolerant species probably die out within 5 to 10 years unless released. These stems should not be confused with suppressed individuals that are essentially the same age as the overstory stems. The timing of the onset of the understory initiation stage is determined by the frequency of minor disturbances of the understory and the shade tolerance of the overstory stems. This phase may occur continuously as advance reproduction develops within canopy gaps and dies out as adjacent crowns encroach into, and eventually close, the gaps, whereas other gaps are opened elsewhere in the stand.

The final old-growth stage may occur if sufficient advance reproduction stems are able to grow into the canopy such that an uneven-aged, multistrata stand develops. True old-growth stands, where a wide range of individuals of widely differing ages and sizes occur in the overstory, are rare in bottomland hardwoods. Major disturbances usually occur before this stage is reached (Meadows, in press).

Regeneration Methods

Clearcutting, whether of entire stands or in smaller portions (i.e., groups, patches, or strips) has the main advantage in that it favors the moderate to intolerant species that are commercially preferred. The clearcutting system may fail, however, if advance regeneration is lacking, an adequate seed source is unavailable, or stump and root sprouts from cut trees are insufficient (Johnson, 1981). Clearcutting is perhaps most problematic from the standpoint of public perceptions and aesthetics.

Clearcutting with reserves has been utilized to try to overcome some of the aesthetic problems found with clearcutting. In clearcutting with reserves, varying numbers of trees are retained to achieve goals other than regeneration. In some states, Best Management Practices (BMPs) stipulate leaving trees for wildlife (e.g., snags and den tree management). In another variation, termed a deferment cut, up to 25 ft^2 basal area per acre is left in vigorous stems of large pole or small sawtimber size. These reserved trees will be carried through until the next rotation. We don't know yet whether these reserved trees will adversely affect regeneration, nor what the public response will be.

Seed-tree methods, in which a small number of trees are left to provide seed, differ from clearcutting with reserves in that the seed trees are removed after regeneration is established. Seed-tree methods only work for light-seeded species, which are generally not a problem to obtain. Hence, seed-tree methods are seldom recommended for bottomland hardwoods as clearcutting almost always produces the same regeneration result (Johnson, 1981).

Shelterwood methods will normally be used in dense, mature stands that have not reached the understory initiation stage of development. A light shelterwood cut, about 10 years before the planned final harvest, may allow moderately intolerant species such as oaks to establish, but this method has produced variable results in bottomlands.

Ideal uneven-aged stands have a mixture of all age classes, and regeneration takes place continuously over the entire area of a stand (Matthews, 1989). Uneven-aged regeneration systems employ some form of selection, either of single trees or small groups of trees; but, an essential feature is to consider all trees as potential crop trees to be retained or as candidates for harvest regardless of diameter (Guldin et al., 1991). Selection systems in hardwoods are difficult to apply, requiring reasonable skill and intensive involvement. In practice, "selective cutting" has been advertised as a silvicultural practice, whereas in reality, it is no more than high-grading, where the best trees are harvested and the poorest left on the site. Many stands today have been degraded by "selective cutting" in the past.

Single-tree selection in bottomland hardwood forests generally does not result in adequate regeneration, because openings are not large enough and close in too quickly for establishment of preferred species (Toliver and Jackson, 1989). Unless initial openings are enlarged within 10 years, stand composition will be pushed toward less commercially desirable, shade-tolerant species. Group selection, in which the diameter of openings is at least twice the height of adjacent trees, may be a suitable method, but intolerant species will be favored only in the interior of the opening. Group selection has been recommended for converting even-aged to uneven-aged stands (Matthews, 1989).

Regeneration Practices

Many mixed hardwood stands in bottomlands have been degraded by past cutting practices, leaving the forester few options other than regeneration. Economic considerations will usually constrain the choices to some form of clearcutting, if adequate advance regeneration or sprouting potential is available. Success, in terms of numbers of stems and species composition, requires full release of the regeneration, meaning trees greater than 2 inches in dbh must be brought back to ground level (Johnson and Shropshire, 1983).

Where regeneration or coppice is not adequate, a two-stage shelterwood may be indicated. Unfortunately, few guidelines have been tested for determining what constitutes adequate regeneration or coppice potential.

Johnson (1980) developed a technique whereby a stand is inventoried prior to harvest and regeneration potential assessed by numerically scoring the reproduction on the site according to species, height, and dbh. Greater weight is given to large oak seedlings. Johnson's method is currently being tested and refined by researchers at the Southern Hardwoods Laboratory and Mississippi State University.

A preliminary evaluation of the prediction model has been published (Johnson and Deen, 1993) and indicates that improvements can be made by modifying the assignment of points, assigning fewer points for smaller desirable seedlings (<1 ft in height). The model is intended only for use with complete overstory removal to ensure that full sunlight will reach the ground. The model is similar to regeneration prediction models developed for other hardwood types in that it emphasizes size, numbers of advance regeneration, and sprouting ability of species in the existing stand (Johnson, 1977; Loftis, 1990; Marquis and Bjorkbom, 1982; Sander et al., 1976).

Prior to harvest, regeneration potential is sampled on 1/100-acre circular plots, approximately one plot per acre. Points are assigned to reproduction (stems less than 5.4 inches in dbh) based upon height classes: 1 point each for stems 1 foot tall or less; 2 points if 1.1 to 2.9 feet tall; and 3 points if 3.0 feet or taller. This accounts for seedlings, seedling sprouts, and saplings.

Points are also assigned for the ability to produce stump sprouts that are competitive and grow well. Because sprouting potential decreases as diameter increases trees smaller in dbh receive higher points than larger trees within a species. For example, red oaks that are 5.6 to 10.5 inches in dbh (that is, the 6- to 10-inch-diameter classes) are assigned 2 points; 10.6- to 15.5-inch trees are given 1 point; but, larger trees receive no points. Sweetgum, on the other hand, has a greater potential to sprout; therefore even trees as large as 20 inches in dbh merit a point.

Two questions remain: When is a plot adequately stocked?, and how many stocked plots are necessary in a stand to give a reasonable assurance that regeneration will be successful? Johnson and Deen (1993) provided preliminary answers to both questions. Twelve points were recommended to consider a plot adequately stocked. This could represent 1,200 trees per acre of stems less than 1 foot tall, or 400 trees per acre of sapling-sized stems over 3 feet tall but less than 5.4 inches in dbh, or some combination of seedlings and stump sprouts. Twelve points are thought to be a conservative criterion and may underestimate the ability of fewer larger stems to survive logging damage and successfully compete. On the other hand, even 12 points may be too few if regeneration is wholly in small seedlings less than 1 foot in height as there is often heavy mortality in this class.

It is uncertain how many stocked plots are necessary. Johnson and Deen (1993) suggested that 60% of the total plots should be stocked to ensure successful regeneration. We are continuing our work to validate Johnson's model.

The Johnson model does not provide a guideline for judging whether oak regeneration will be successful. The model will predict no oak regeneration if the existing stand contains no oaks of sprout-producing size nor any oak seedlings and does not account for new germinants that become established after harvest.

Nix and Lafaye (1993), for example, found a happy coincidence of a good acorn crop just prior to harvest, substantial scarification during logging due to a wet site, and complete removal of all merchantable stems, combined to produce several thousand oak seedlings per acre. They reported that survival after 5 growing seasons was between 700 and 1,000 seedlings per acre, with as many as 60% in a competitive position. For the most part, however, because of seed crop variability, it would be unwise to rely solely on new germinants to maintain a desirable oak component in bottomland hardwood stands. Experience in other oak types suggests that large advance reproduction, at least 3 feet to 5 feet in height, will probably be needed.

Partial Cutting

If oak regeneration potential is poor, the manager has three options (Clatterbuck and Meadows, 1993): promote advance regeneration through understory removals or partial overstory thinning; increase oak regeneration by supplemental planting or direct seeding; or convert to a plantation. We will address only the first option, partial cutting.

The objective of classical shelterwood treatments is to increase light to the forest floor so that oak seedlings can establish and grow to the larger size classes before the overstory is removed. This presumes, of course, that there are enough oaks of sufficient vigor in the overstory to produce good acorn crops. Once seedlings are established, further cuts are needed to maintain their survival and growth.

Stands with dense understories and midstories of tolerant species will require deadening or removal of undesirable, lower canopy stems to provide adequate light to the forest floor (Janzen and Hodges, 1987). We don't have enough experience or data to recommend cutting intensity, number of cuts and the intervals between them, or the degree of competition control necessary.

Heavy shelterwood removals will favor fast-growing intolerants, and light cuts may favor less desirable tolerant species. This is an area where further research is needed.

Partial cutting has been practiced as well to improve overstory composition and control stand density. The desirable result of increased growth of residual trees has been mixed with undesirable results of increased epicormic branching and logging damage to residual stems. While some logging damage is unavoidable, the potential impact on future stand value can be excessive.

Logging wounds provide a site of entry for pathogenic fungi that cause butt rots, the primary cause of cull in southern hardwoods (Toole, 1960). The average extent of rot above a scar in red oaks is 2.7 feet, 20 years after wounding and 5.4 feet after 40 years. If a scar is already 2 to 3 feet long, a significant portion of the butt log could be lost by the time a stand is harvested (Toole, 1960).

Research at the Southern Hardwoods Laboratory is looking at logging damage as part of a larger effort devoted to intermediate stand management. In one study of partial cutting in a green ash-sugarberry stand, excessive logging damage was found (Meadows, 1993). Thinning removed 40% of stems and 25% of basal area from below. Fully 62% of the residual trees were damaged to some extent, primarily to the lower bole or to exposed lateral roots. While damage to most trees was minor, 35% experienced moderate to severe damage. Skidding damage was the most common form of damage.

Besides offering an infection site for pathogens, logging wounds stress the tree and lower its vigor. We are investigating whether this also causes an increase in epicormic branching. While epicormics did not significantly increase 1 year after harvest in the green ash-sugarberry stand, the full impact may not be evident for several years.

Reisinger and Pope (1991) investigated logging damage in upland hardwood stands in Indiana that were harvested using a combination of single-tree and group-selection methods. They also found excessive damage (71%), primarily from skidding. They concluded that much of the skidding damage was due to carelessness. They recommended that logging damage be minimized by making certain that skidder operators be given training and made aware of the value of the residual crop. They also thought that closer supervision and alternatively financial incentives or penalties specified in the logging contract would help. Preharvest planning and designated skid trails, along with designated "rub" trees along main skid trails, may be especially important in uneven-aged management. These techniques would concentrate adverse impacts on residual trees and the site into a smaller area.

Future Directions

Economics dictate that reliance on natural regeneration in bottomland hardwoods will continue. Maintaining the valuable oak component will be a major challenge as it has proven to be on productive upland sites. More than ever, managers need proven techniques for predicting regeneration outcomes from various treatments. Although we continue to validate Johnson's prediction guide, it is only applicable for complete overstory removal. Prediction techniques robust enough to apply to other regeneration treatments are needed. Social pressure, particularly on public land managers, dictates that even-aged regeneration alternatives to complete clearcutting that still result in adequate regeneration of desirable intolerant species need to be developed. While deferment cuts may be a viable method, this has to be demonstrated experimentally and operationally.

Experience has shown that classical shelterwood methods are not reliable enough to regenerate oaks in one or two partial cuts. Limited data suggest that understory control may be as important as overstory reductions in establishing and maintaining advance oak reproduction. Future research should be directed toward quantifying the light conditions on the forest floor necessary at different stages of seedling development and establishing relationships between light levels and amounts of overstory and understory leaf area. Understanding these relationships will allow the development of guidelines on cutting intensity, number of cuts and intervals between them, and the degree of competition control necessary.

Textbook uneven-aged management in bottomland hardwoods will seldom be practiced on nonindustrial private land. Even on public and industrial land, the expertise and commitment needed to successfully apply "true" group selection will seldom be available. What appears practical is a hybrid method that some will call group selection but purists will regard as a patch clearcut or shelterwood. In stands that have not been severely high-graded, this method seems to work. In any case, partial cuts will be increasingly prescribed for promoting advanced oak regeneration by shelterwood, or for uneven-aged management. In the future, special care must be taken to avoid logging damage during harvest. An aggressive program of logger education, at the level of the machine operator, seems warranted.

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